SIM Science Studies:

Stellar Astrophysics with SIM

Calibration and Characterisation across the HR diagram

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reporting on studies by PIs

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The Space Interferometry Mission offers the opportunity to obtain astrometric accuracies at the level of a few microarcseconds.

This will make it possible to obtain trigonometric parallaxes across the entire Galaxy

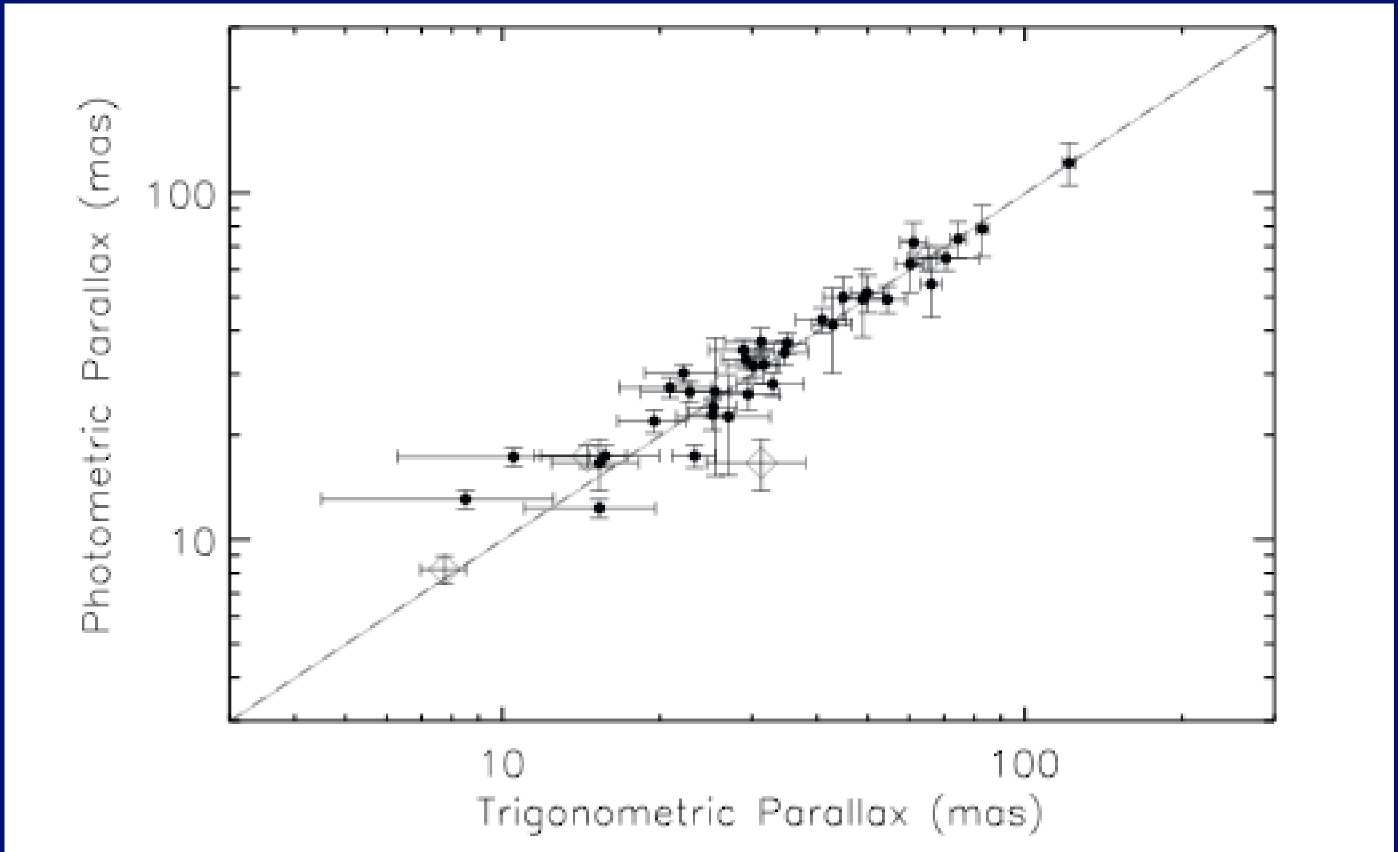
#8: A Novel SIM-based technique for the precise determination of absolute stellar fluxes

(Holberg & Bergeron)

The goal of this study is to calibrate the absolute spectrophotometry of well-understood white dwarfs, using accurate parallaxes, to better than 1%

Motivation includes the idiosyncratic nature of Vega, the need to extend accurate flux standards to the near-IR to enable high-redshift work, and the need for a stable, accurate, all-sky flux standard for pan-chromatic, wide-field surveys (e.g. LSST)

A flux standard based on DA white dwarfs has the advantage that such stars are numerous, nearby (unreddened), chemically homogeneous and accurately reproduced by theoretical models



$$f_\lambda = 4\pi H_\lambda (T_{eff}, \log g)(\frac{R^2}{D^2}),$$

Photometric parallax is based on broad band photometry and atmosphere models

The addition of SIM parallaxes promises to take this calibration to well below a level of 1%. However, this can expose other systematics that this SIM study proposes to address.

One of these is the accuracy of the spectroscopic gravity used to determine the radius - at high temperatures it can be affected by radiative levitation, and at low temperatures by convective dredge-up of Helium.

Another is the effect of white dwarf mass and internal composition on the radius, since the mean molecular weight is a contributor, as well as small contributions from non-degenerate layers, in the hotter stars.

#15: Stellar Astrophysics with SIM and Optical Long Baseline Interferometry

(Ridgway, Aufdenberg, Gies, Howell, Kervella & Merand)

This study has several goals:

One is the improved calibration of the Cepheid distance scale using trigonometric parallaxes

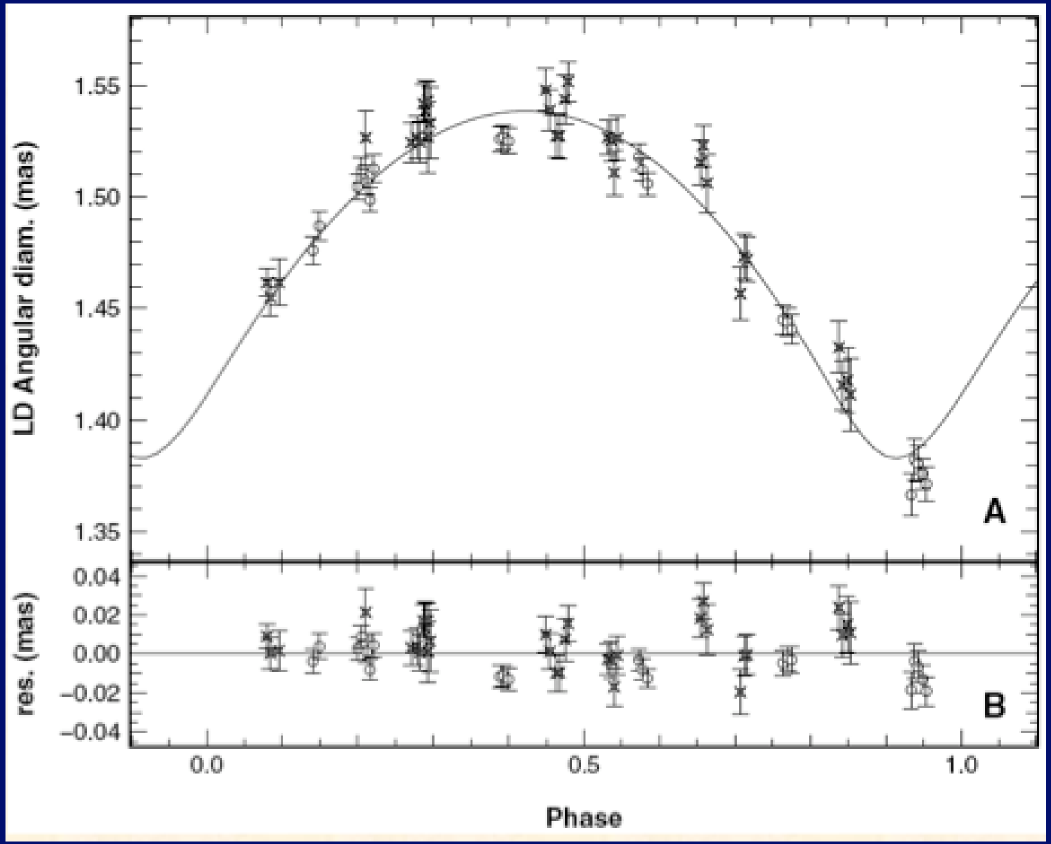
Another is the measurement of radii and luminosities of massive stars

A third is the determination of orbital parameters for complicated interacting binaries

A fourth is the combination of distance and asteroseismological measures to accurately characterise nearby stars

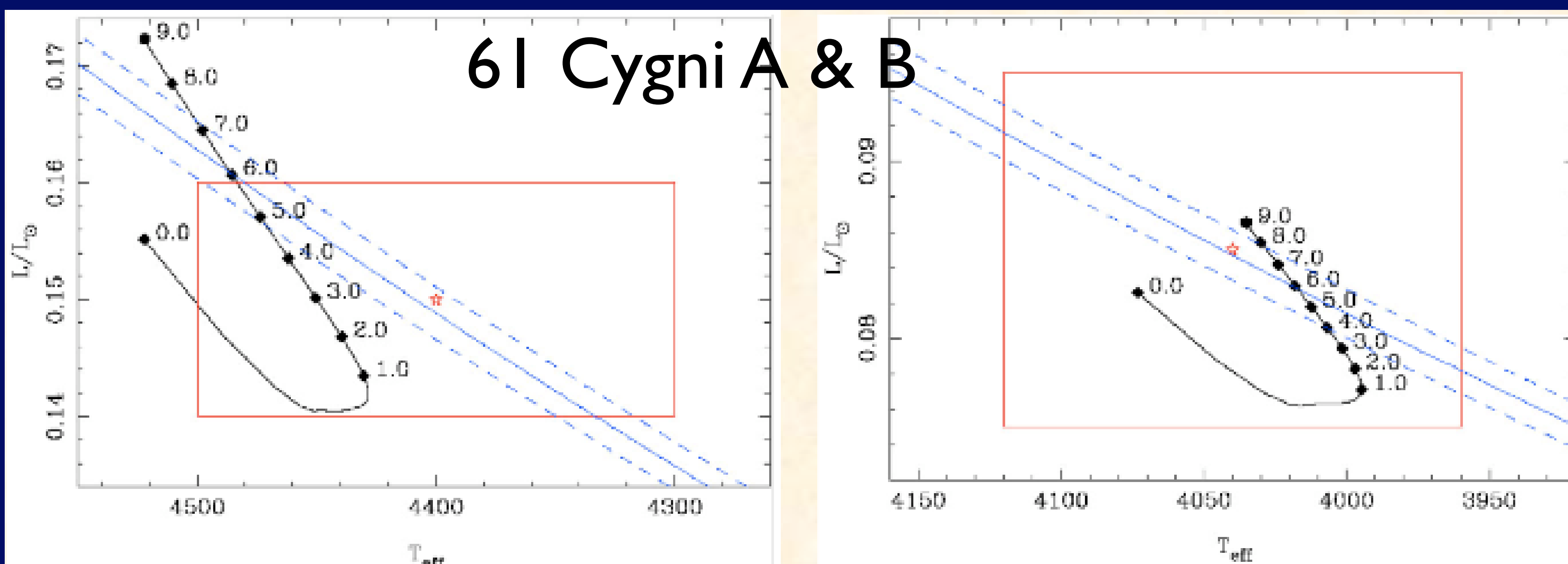
SIM parallaxes will allow the determination of distances to non-LMC Cepheids, thereby accounting for metallicity dependance.

Calibration of the P-L relation by the Baade-Wesselink method requires connecting the pulsational velocity of the photosphere with the radial velocity measured from spectra (which is a disk-integrated quantity).



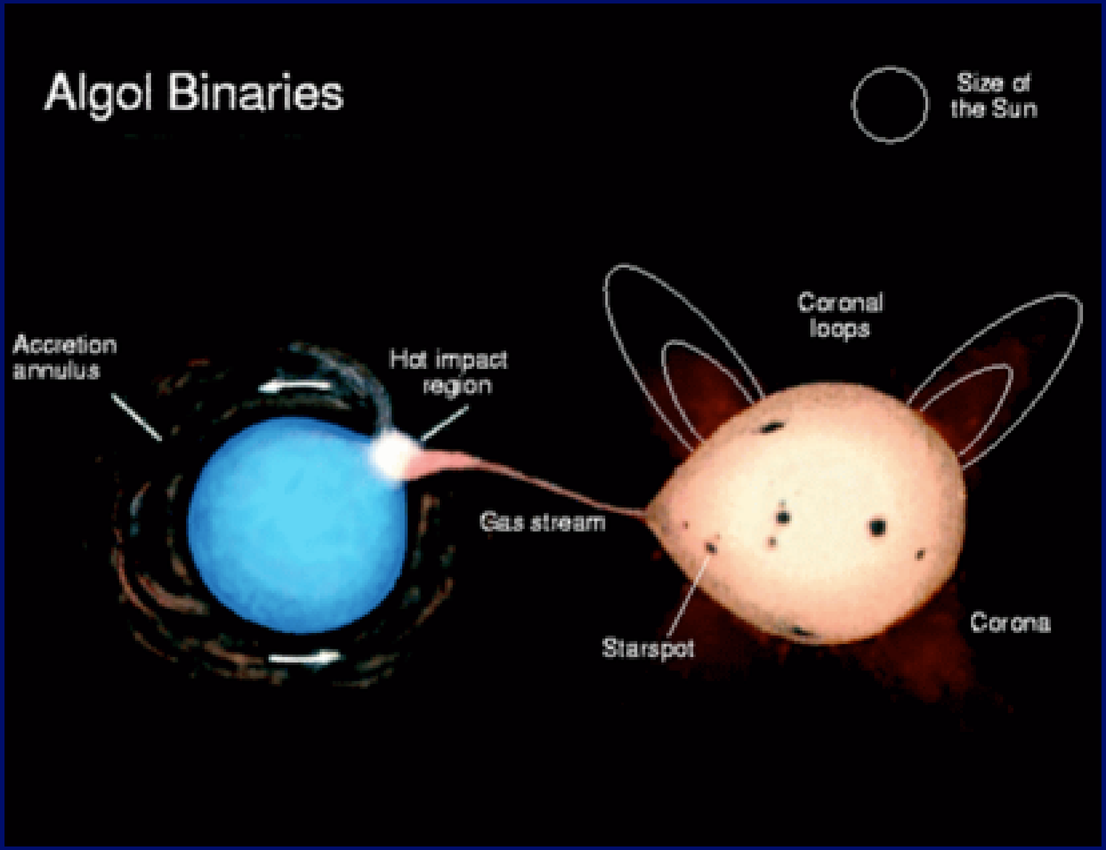
Interferometry can measure the angular diameter pulsations, which can be converted into velocity with accurate distances

The combination of interferometry and astrometry can also provide excellent constraints on the structural parameters (mass, age) of nearby stars. Angular diameters provide a range of allowed radii, depending on the distance, so that a good astrometric constraint amounts to a narrow allowed locus in the H-R diagram.



The addition of asteroseismic observations can also constrain the mass

The properties of many Cataclysmic Variable binaries suggest that significant mass re-arrangement occurred between the two stars before one became a white dwarf. This suggests a link with Algol systems. Orbital parameters and masses for a selection of post-Algol binaries will provide information as to the intermediate stage between these two better studied evolutionary epochs.



Distances to Massive Stars - correcting a huge blind spot in the current astronomical canon

#5: Parallax Observations of Local Supergiants

(Jiao)

#?: Calibrating the Spectroscopic Distance Scale using Runaway O and Wolf-Rayet Stars

(Hartkopf & Mason)

+ some of the Ridgway proposal as well

All of these authors address the same basic point - that massive stars are poorly understood relative to their lower mass compatriots. This is a result of their relative rarity, which means that they lie at greater distances on average and have correspondingly poorer parallaxes. They are also often too bright for the more sensitive instruments designed to study fainter objects.

SIM can dramatically improve this with 1% accuracy to several kiloparsecs. This will allow for a much better understanding of massive star luminosities at various evolutionary stages, and a corresponding improvement in our understanding of such subjects as supernova progenitors and the maintanence of heating and ionization balance in the ISM.

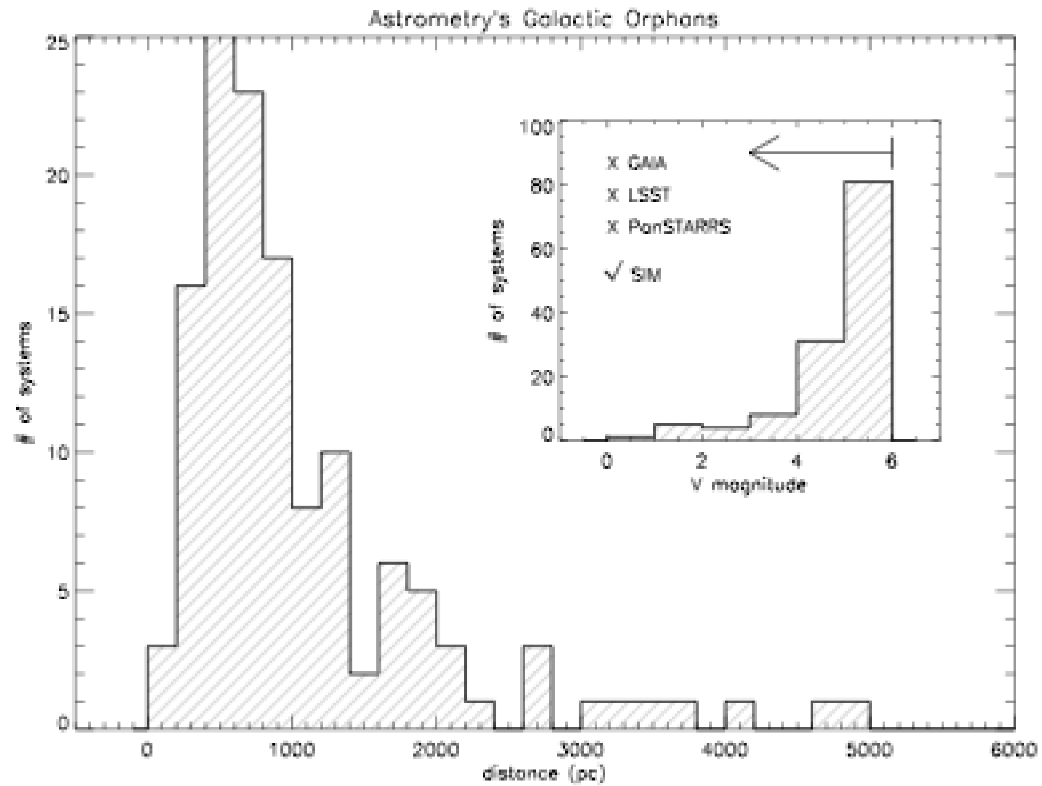
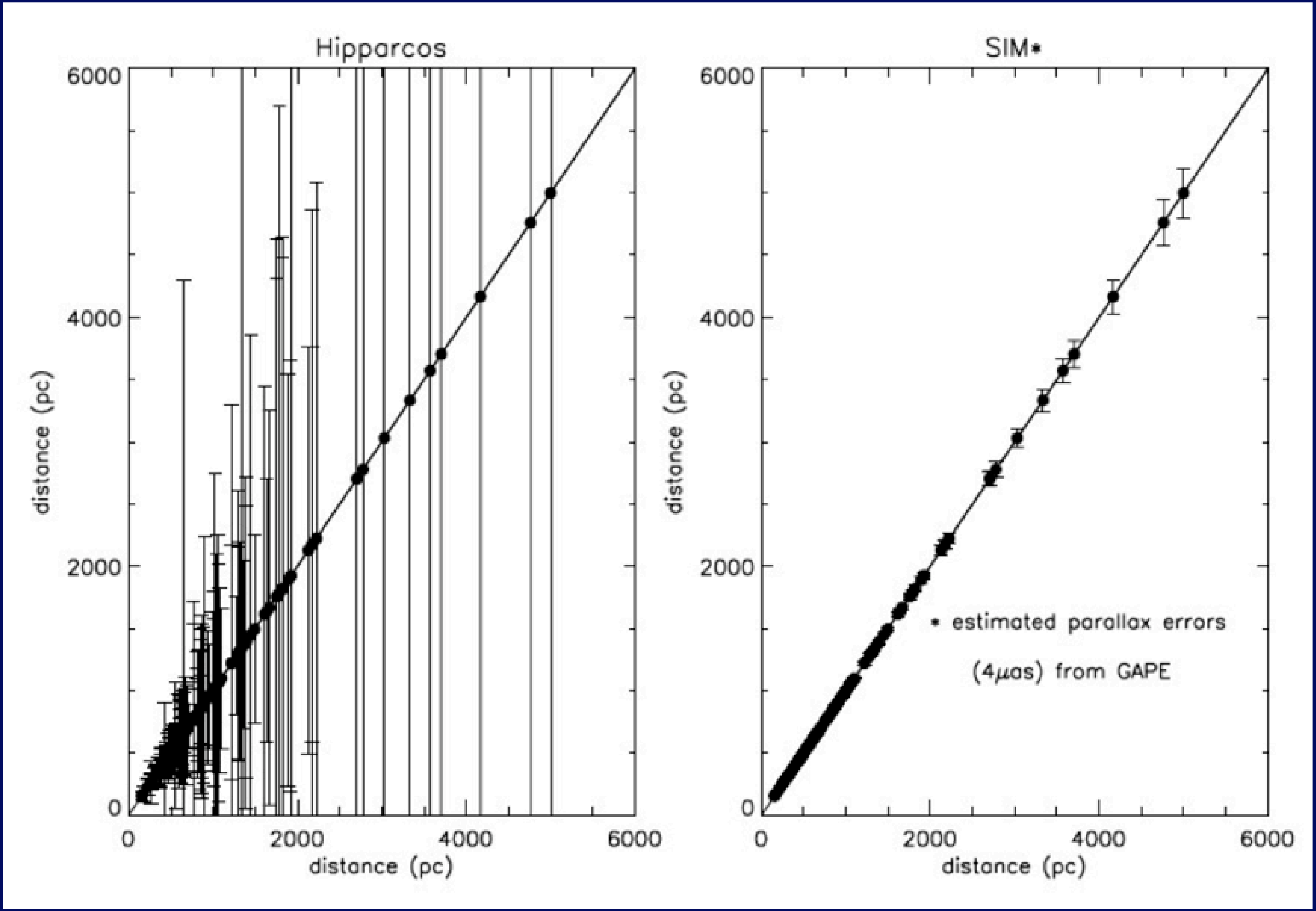


Figure 2: The supergiants from Hipparcos shown in Figure 1 are distributed throughout solar neighborhood out to as far as 5 Kpc. The inset histogram shows their magnitudes. None of these stars is observable with Pan-STARRS, LSST, or Gaia.

Jao - distances to supergiants, will constrain late evolutionary stages and bright stars. This will also allow for better calibration of proposed extragalactic distance indicators based on supergiants.



Dramatic improvements over current state of the art are clearly useful.

O and B stars will also benefit from better luminosity calibration. Ridgway et al propose to combine interferometric measurements of angular diameters with SIM astrometry and spectroscopic effective temperatures.

Hartkopf & Mason address other systematics in this measurement such as high multiplicity, crowded fields and interstellar extinction by proposing to build a sample of O and B runaway stars using the latest proper motion catalogues.

Summary

I have chosen here to focus on the science enabled by the SIM science studies. The actual funding periods were sufficiently limited that the work performed under these grants was necessarily preparatory in nature.

However, the science that could potentially emerge from these preparations indicates the applicability of SIM to a wide and diverse variety of subjects of interest to the astronomical community.